PULSE WIDTH MODULATED SOLENOID

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The instant application claims priority to U.S. Provisional Patent Application Serial No. 60/474,774, filed May 30, 2003, the entire specification of which is expressly incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention generally relates to solenoid control valves, and more particularly to a pulse width modulated solenoid control valve for controlling hydraulic functions of a transmission for a vehicle.

BACKGROUND OF THE INVENTION

[0003] Various solenoid designs have been used in the automotive industry, including those for use in conjunction with automatic transmission systems. For example, automatic transmission control systems generally employ solenoids in order to control the pressure and flow of the transmission fluid. In this manner, the control of transmission fluid pressure can be used to engage and disengage a transmission clutch in response to an electrical input signal supplied to the solenoid, or the control of transmission fluid pressure can be used to maintain transmission line pressure.

[0004] Generally, solenoids employ a solenoid control valve to aid in the regulation of the fluid flow by the solenoid. An example of a solenoid control

valve can be found in U.S. Patent No. 4,998,559 to McAuliffe et al., the entire specification of which is incorporated herein by reference. Recently, the use of pulse width modulated solenoids has become more prevalent in certain automotive applications.

[0005] Although pulse width modulated conventional solenoid control valves have been somewhat successful in meeting the demands of the automotive industry, these pulse width modulated solenoid control valves can be further improved upon, e.g., in the areas of cost, quality, performance, and the like.

[0006] Accordingly, there exists a need for new and improved pulse width modulated solenoid control valves.

SUMMARY OF THE INVENTION

[0007] A new and improved solenoid control valve is provided, in accordance with the general teachings of the present invention. More specifically, a new and improved pulse width modulated solenoid control valve is provided, in accordance with one embodiment of the present invention

[0008] The solenoid control valve preferably employs a plastic control valve body that preferably includes a segmented flow path that adds strength to the supply tube portion. In accordance with a preferred embodiment of the present invention, a stepped coil portion is preferably provided. In accordance with another preferred embodiment of the present invention, an actuation rod is preferably provided that is tapered adjacent to and contacting the armature so as

to reduce flux shorting and improve operating characteristics. Accordingly, the solenoid control valve of the present invention preferably provides a characteristic performance curve.

[0009] In accordance with a first embodiment of the present invention, a solenoid fluid control valve is provided, comprising: (1) a fluid control body adapted for being received in a fluid housing, said fluid control body including a central cavity, and having a pressure supply passage at a first end and a radially extending pressure control passage; (2) a feed supply tube positioned in said central cavity, said feed supply tube including an outer diameter in communication with the pressure control passage, and including an inner bore operably connected to said pressure supply passage, said feed supply tube being supported in said central cavity of said fluid control body by way of a radially and axially extending wall, said wall being segmented into a plurality of longitudinally extending flow chambers, said feed supply tube including a valve receiving chamber area; (3) a valve seat portion being made of a metallic material and press fit into said fluid control body, said valve seat portion including a valve seat and a passage in communication between said valve seat and said pressure control passage; (4) a valve contained in said valve receiving chamber operable to selectively close off communication between said pressure supply passage and said pressure control passage; and (5) a solenoid for opening said valve in response to a signal.

[0010] In accordance with a second embodiment of the present invention, a solenoid fluid control valve is provided, comprising: (1) a fluid control

body adapted for being received in a fluid housing, said fluid control body including a central cavity, and having a pressure supply passage at a first end and a radially extending pressure control passage; (2) a feed supply tube positioned in said central cavity, said feed supply tube including an outer diameter in communication with the pressure control passage, and including an inner bore operably connected to said pressure supply passage, said feed supply tube being supported in said central cavity of said fluid control body by way of a radially and axially extending wall, said wall being segmented into a plurality of longitudinally extending flow chambers, said feed supply tube including a valve receiving chamber area; (3) a valve seat portion being made of a metallic material and press fit into said fluid control body, said valve seat portion including a valve seat and a passage in communication between said valve seat and said pressure control passage; (4) a valve contained in said valve receiving chamber operable to selectively close off communication between said pressure supply passage and said pressure control passage; (5) a solenoid for opening said valve in response to a signal, wherein said solenoid includes a central axis and has a coil wound around a bobbin, spaced from and positioned around said central axis, said coil having radially stepped radial inner diameters; (6) a casing member for attaching said solenoid to said fluid control body; a portion of said casing member extending into the stepped portion of said coil for forming a flux tube therein; and (7) an armature axially movable within said bobbin.

[0011] In accordance with a third embodiment of the present invention, a solenoid fluid control valve is provided, comprising: (1) a fluid control body

adapted for being received in a fluid housing, said fluid control body including a central cavity, and having a pressure supply passage at a first end and a radially extending pressure control passage; (2) a feed supply tube positioned in said central cavity, said feed supply tube including an outer diameter in communication with the pressure control passage, and including an inner bore operably connected to said pressure supply passage, said feed supply tube being supported in said central cavity of said fluid control body by way of a radially and axially extending wall, said wall being segmented into a plurality of longitudinally extending flow chambers, said feed supply tube including a valve receiving chamber area; (3) a valve seat portion being made of a metallic material and press fit into said fluid control body, said valve seat portion including a valve seat and a passage in communication between said valve seat and said pressure control passage; (4) a valve contained in said valve receiving chamber operable to selectively close off communication between said pressure supply passage and said pressure control passage; (5) a solenoid for opening said valve in response to a signal, wherein said solenoid includes a central axis and has a coil wound around a bobbin, spaced from and positioned around said central axis, said coil having radially stepped radial inner diameters; (6) a casing member for attaching said solenoid to said fluid control body; a portion of said casing member extending into the stepped portion of said coil for forming a flux tube therein; (7) an armature axially movable within said bobbin; (8) a pole piece assembly adjacent said armature and interposed between said bobbin and said fluid control body; and (9) a control rod extending along said central axis and

through said pole piece assembly for opening of said valve, said control rod including a tapered end.

[0012] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description and specific examples, while indicating the preferred embodiment of the invention, are intended for purposes of illustration only and are not intended to limit the scope of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0014] Figure 1 is a cross-sectional view of the solenoid control valve of the present invention;

[0015] Figure 2 is a side view of the control valve body of the present invention;

[0016] Figure 3 is a top view of the control valve body of the present invention;

[0017] Figure 4 is a sectional view taken along line 4-4 of Figure 2;

[0018] Figure 5 is a sectional view taken along line 5-5 of Figure 2;

[0019] Figure 6 is a sectional view taken along line 6-6 of Figure 2;

[0020] Figure 7 is a sectional view taken along line 7-7 of Figure 2;

[0021] Figure 8 is a second partially broken away sectional view of the valve body of the present invention;

[0022] Figure 9 is a performance curve of the operational characteristics of the present invention when operating at 40 psi;

[0023] Figure 10 is a performance curve of the operational characteristics of the present invention when operating at 120 psi; and

[0024] Figure 11 is a performance curve of the operational characteristics of the present invention when operating at 215 psi.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0026] Referring to the Figures generally, and Figs. 1-8 specifically, there is provided a solenoid control valve generally shown at 10, in accordance with the general teachings of the present invention. The solenoid control valve includes a fluid control body generally indicated at 12, and a solenoid portion generally indicated at 14. By way of a non-limiting example, the fluid control body 12 is preferably adapted for being received in a fluid manifold housing in a valve body of a transmission.

[0027] The fluid control body 12 preferably includes a central cavity 16, wherein the central cavity 16 preferably includes a fluid supply passage 18 and a fluid control passage 20. These passages preferably communicate with either a supply line in the manifold or a control line, as is readily known in the art. A feed supply tube 22 is preferably integrally molded with the fluid control body 12.

Feed supply tube 22 preferably includes an outer diameter 24, which is in communication with the control passage 20, and preferably includes an inner bore 26 in communication with the supply passage 18 through laterally extending port 28. The feed supply tube 22 is preferably supported in the cavity 16 by at least one or more segmented areas 30, best shown in Fig. 6. Preferably, there are three segmented flow passages on each side of the feed supply tube 22, as shown in Fig. 6. The feed supply tube 22 preferably includes a valve receiving area 32.

[0028] A valve seat-forming portion 34 is preferably made out of a metal material and is press fit into the feed supply tube 22. The outer diameter of the valve seat-forming portion 34 is preferably press fit into the valve receiving area 32. By this arrangement, fluid passage is allowed to flow axially through the segmented area 30, while the webs forming the segmented area absorb press loads on the valve seat member 34. An alignment shelf 36 is preferably provided on the control body for providing proper depth of alignment of the valve seat member 34. A ball valve 38 is preferably held between the valve seat 40 and the valve retainer portion 32. A return spring 35 preferably biases the ball valve 38 toward valve seat 40. The valve seat member 34 preferably provides a passageway 42 to the control passage 20. The valve 40 is preferably operable to selectively cut off supply of flow from the supply channel 18 to the control passage 20.

[0029] The valve seat member 34 is preferably press fit into the flux washer 62 forming a pole piece assembly 64. In a preferred embodiment, the

flux washer 62 is preferably a stamped member and the valve seat member 34 is preferably a screw turned member. Assembly of these pieces together reduces the cost of the assembly.

[0030] Solenoid portion 14 is preferably secured to the fluid control body 12. An O-ring 44 is preferably disposed between the fluid control body 12 and the pole piece assembly 64. The solenoid 14 preferably includes a central axis A-A and has a coil 46 wound around a nonmagnetic bobbin member 48. The bobbin member 48 is preferably stepped radially, and includes a radially outward wall 52 and a radially inward wall 54. A one-piece casing member 50 preferably includes a radially extending flux tube forming annular portion 56. The casing 50 also preferably crimpingly attaches the solenoid 14 to the body 12 by way of the crimped portion 58. An armature 60 is preferably provided, which fits within the wall 54 and is axially movable in response to a current in the coil. The pole piece assembly 64 is preferably secured between the lower portion of the bobbin 48 and the control body 12. The pole piece assembly 64 preferably includes a center orifice 64, which allows the valve seat member 34 to be press fit therein.

[0031] The control rod 66 preferably has a tapered upper end 67 and is movable within the member 34. The armature 60 preferably moves the control rod 66. The tapered pin preferably reduces magnetic flux shorting, thereby improving performance without sacrificing strength.

[0032] Assembly standoffs 69 are preferably provided. These standoffs are preferably axially radially extending rib members. These rib

members act to preferably provide precise positioning of the casing 50 in the final solenoid control valve of the present invention. Specifically, a retention groove 76 is preferably provided that is engaged by a clip member (not shown) when securing the control valve 10 in a fluid manifold housing in a valve body of a transmission, for example. In the past, getting the fluid control body 12 axially positioned properly in the manifold housing for alignment of the clip with slot 76 has been problematic. These ribs ensure precise alignment during assembly for the clip to engage slot 76. A preferred embodiment has two ribs 76 spaced 180° apart and a wider rib 76a positioned 90° between these ribs 76.

[0033] The coil 46, bobbin 48 and coil contacts 70 are preferably overmolded to form connector 72. This forms a one-piece assembly that also preferably includes an armature cage assembly 72A portion that preferably holds armature 60 and its biasing spring 74 in place upon securement of the casing 50 to the fluid control body 12.

[0034] Set forth in Figures 9 through 11 are transfer function progressions showing the duty cycle performance of the pulse width modulation of the solenoid of the present invention when operating with 40, 120 and 215 pounds per square inch of fluid pressure applied at the supply passage. As shown therein, the performance characteristics are optimized in the design of the present invention.

[0035] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended

to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.